SKIN FOR AUTOMOTIVE AIR BAG COVER PANEL FORMED BY CASTING DIFFERENT PLASTIC MATERIALS

TECHNICAL FIELD

This invention relates to plastic automotive interior skins and air bag cover skins and, more particularly, to a combination of the two.

BACKGROUND OF THE INVENTION

In manufacturing automotive interior panels that include air bag deployment portions, it is common practice to use vinyl, typically polyvinyl chloride (PVC), to form a thin soft pliable outer shell or skin for the panel. The skin material may also include the use of urethanes (e.g., PU) olefins (e.g., PP, PE, TPO, ETP-TPO), esters (e.g., COPE), styrenes (e.g., ADS, ASA) and rubbers (e.g. TPO, ETP-TPO, ABS) in various compositions. One side of a soft plastic foam layer is then bonded to the skin and the other side of the foam layer is bonded to an injection-molded plastic substrate. The substrate may also be constructed from materials such as metal, plastic composite or wood fiber composite using other forming techniques well known in the art. The skin, including its air bag cover portion, is commonly formed by casting or spraying plastic material against a heated mold surface that defines the desired shape of the appearance side of the panel. Two examples of materials that may be used in casting shells include miniature spherical (0.020") pellets formed by extruding plastic through a very small die, and a powder formed by using a high intensity mixer to diffuse plasticizer and colorant into PVC resin particles to yield a particle size averaging 300 microns. The mold is commonly referred to as a shell tool and typically has an electroformed nickel surface that produces a grained surface or other desired texture on the outer side of the skin for styling purposes.

It is also common practice to provide a tear seam in the air bag cover portion of the skin that air bag inflation force tears open to allow the air bag to deploy. The tear seam may be formed in various ways in the air bag cover skin such as with a visible weakening groove in the outer side, a hidden weakening groove in the back side or with a tear seam strip of relatively weak plastic material that is incorporated in the cover skin and may be hidden from view by painting the air bag cover. The opening for the air bag in the cover skin may also be formed by a cutting device located behind the skin. The substrate also includes suitable means, such as a hinged door arrangement; to create an opening in the substrate corresponding to the opening created in the cover skin. Upon air bag deployment a portion of the skin and a portion of the foam layer become the outer and intermediate layers, respectively, of such a door or doors and swing outward with the door or doors.

Certain polyvinyl chloride (PVC) formulations such as Drysol compounds DL1011 and DL1013 are well suited, in durability, fade and heat resistance, to meeting the general requirements of an instrument panel skin which is subject to sun rays passing through a proprietary formulations of PVC resins, plasticizers, stabilizers and pigments. Their formulations may include, but are not limited to the following: 50 to 60% PVC resin by weight, 30 to 45% plasticizer by weight, and 0.1 to 5% pigment by weight. On the other hand, the air bag cover requirements further include the ability to remain ductile at very low temperatures to prevent the cover from fragmenting when an inflating air bag impacts it. Because of cold embrittlement, PVC formulations such as

DL1011 and DL1013 cannot provide for satisfactory air bag deployment performance. These PVC formulations tend to fragment at the extremely low temperatures that some automobile manufacturers specify. This is particularly true where a tear seam is formed in the skin or a cutter device is used to create an air bag deployment opening. To meet such extreme low temperature ductility requirements, a completely separate air bag door of PVC or other plastic materials may be installed in the instrument panel to obviate the need to tear or cut the PVC skin of the instrument panel to create an opening for the air bag. However, some automobile manufacturers prefer a hidden door. A completely separate air bag door is both difficult to hide and costs more than a skin having an integral tear seam that is either visible or hidden.

Certain PVC formulations such as Drysol compound DL3020, and certain polyurethane (PU) elastomers remain elastic or ductile at temperatures substantially below where PVC formulations such as Drysol compounds DL1011 or DL1013 become brittle or inelastic. However, PU and DL3020 are relatively expensive compared to DL1011 and DL1013. DL3020, for example, costs about 50% more than DL1013. In other words, standard PVC formulations such as Drysol compounds DL1011 and DL1013 are very well suited to general instrument panel skin requirements and are cheaper than PU and DL3020, but are not as ductile as PU or DL3020 at extremely low temperatures. There have been various attempts to cost-effectively meet the different instrument panel and air bag cover requirements with a single skin structure. However, it has proven to be especially difficult to cost-effectively design an instrument panel with satisfactory air bag deployment characteristics at extremely low temperatures.

SUMMARY OF THE INVENTION

The present invention provides a very cost-effective way to meet the differing requirements of an instrument panel skin and an air bag cover panel skin by forming a single plastic air bag cover panel skin from different polymeric materials. In particular, the present invention provides a way to meet the extreme low temperature requirements of the air bag deployment portion of an air bag cover panel skin by using a relatively inexpensive first plastic material to form a main body skin portion that covers most of the panel and using a second plastic material to form an air bag cover skin portion that is incorporated in the main body skin portion.

According to the invention, the main body skin portion comprises a skin casting made of a first plastic material and the air bag cover skin portion comprises a skin casting made of a second plastic material. The second plastic material has the property of remaining substantially more ductile with decreasing temperature than the first plastic material. A plastic bond, which may comprise a third plastic material or an overlap of the first and second plastic materials, attaches the main body skin portion to the air bag cover skin portion. An air bag deployment region is disposed centrally in the air bag cover skin portion adjacent the air bag deployment portion of the panel and is remote from the main body skin portion. The air bag deployment region is adapted to open in response to the force of an inflating air bag.

According to another aspect of the present invention the first plastic material is preferably a polyvinyl chloride (PVC) material and the second plastic material is preferably polyurethane (PU). Alternatively, the second plastic material may be a second PVC material.

According to another aspect of the present invention the backside of the air bag deployment region of the air bag

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cover skin portion may include a tear seam-defining groove. Alternatively, the air bag deployment region of the air bag cover skin may include an integral tear seam strip. The tear seam strip may comprise a combination of a weakening filler material with either PU or PVC—depending on which material is more suitable of use with the material comprising the airbag cover skin portion. Either combination will make the tear seam strip substantially weaker than the rest of the air bag cover skin portion.

According to another aspect of the present invention a method is provided for forming A skin for an automotive interior panel where the skin comprises a main body skin portion for covering most of an outer surface of the panel and an air bag cover skin portion bordered by the main body skin portion for covering the air bag deployment portion of the air bag cover panel. The main body skin portion is formed by casting a first plastic material against a first surface area of a heated shell tool to form a first plastic skin casting to the desired shape of the main body skin portion. The air bag cover skin portion is formed by casting or spraying a second plastic material against at least a second surface area of the heated shell tool to form a second plastic skin casting to the desired shape of the air bag cover skin portion.

The steps of forming the main body skin portion and forming the air bag cover skin portion may be performed simultaneously by confining the second surface area from the first surface area and simultaneously casting the first and second plastic materials against the respective confined first and second surface areas. Alternatively, the step of casting the main body skin portion may be performed sequentially before the step of casting or spraying the air bag cover skin portion by first masking-off the second surface area of the shell tool then casting the first plastic material against the first surface area, unmasking the second surface area, then casting or spraying the second plastic material against the second surface area The second plastic material may also be cast or sprayed against the layer of plastic material on the first surface area, or a portion thereof, to create a material overlap.

According to another aspect of the present invention where simultaneous casting of the first and second plastic materials against the respective confined first and second surface areas is performed, a bond is formed that attaches the main body skin portion and the air bag cover skin portion together along their respective inner and outer edges while the skin portions remain on the heated shell tool. The bond may be formed by spraying a plastic bonding material between, or between and overlapping, the inner edge of the main body skin portion and the outer edge of the air bag cover skin portion. Alternatively, where the step of casting the main body skin portion is performed sequentially before the step of casting or spraying the air bag cover skin portion, the bond preferably is created by an overlap of the first and second plastic materials.

According to another aspect of the present invention where a plastic bonding material must be used to join the first and second plastic materials, the bonding material must be of a form and composition capable of adequately bonding to both first and second materials as well known in the art. Preferably, the form of the material as applied is either that of a powder or liquid, which may be, applied though a conventional spray gun or spray apparatus. The plastic material(s) contained in either the powders or liquids may be of a completely thermoplastic nature or may contain a chemically reactive component, which makes them partially or completely thermoset after cure. In the instance of ini-

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tially liquid bonding materials, the plastic bonding material may or may not be required to be in solution (either aqueous or non-aqueous) , in order to make the plastic bonding material capable of being sprayed. Examples of preferable plastic bonding materials include both powder and liquid vinyls and urethanes. In order to spray liquid PVC it typically must be provided in a non-aqueous solution. Conversely, sprayable reactive liquid urethanes are not necessarily required to be in solution given that the reactive components are normally liquids and capable of being sprayed

The process may also include the step of forming a tear seam in the air bag cover skin portion. The tear seam may be formed by scoring the back side of the air bag cover skin portion with a laser beam or by pressing a heated impression tool into the back side of the air bag cover skin portion. Alternatively, the step of forming a tear seam may include casting the second plastic material about a tear seam gap-defining gasket. The second plastic material may consist of either polyurethane or a polyvinyl chloride The gasket may have an X, H, C U or I shape and may be supported within a second powder box. The gasket is pressed against the second surface area to form the tear seam-defining gap in the air bag cover skin portion upon gasket removal. The gap is filled with a plastic material by spraying or casting the plastic material to form a tear seam strip in the plastic skin casting while this casting remains on the second surface area The gap may be filled by spraying or casting the plastic material, which may consist of a polyvinyl chloride material or a polyurethane with a weakening filler material.

Finally, a coat of paint may be applied to cover an outer surface of both skin portions, the bond and the tear seam strip The paint is applied to hide both the bond and the tear seam strip from view and to present a more aesthetically pleasing appearance.

Thus, to reduce cost, the air bag cover panel skin of the present invention is mainly formed with the relatively low cost first plastic material And, unlike prior art air bag cover skins, only the air bag cover portion of the panel that is directly impacted by the air bag is covered with a relatively high cost material with superior low-temperature properties. The superior low temperature properties of the relatively high cost materials prevent them from fragmenting at low temperatures when the air bag inflates and breaks open the air bag cover skin portion. The invention limits the direct air bag impact zone to the air bag cover portion surrounding the air bag deployment opening. Therefore the main body skin portion is not subjected to air bag impact and is prevented from fracturing. Moreover, casting shell tools used to form an instrument panel shell or skin are normally electroformed with a grained surface to impart a certain desired grained texture to the entire appearance surface of the panel. Therefore, in the present invention, a stylist is provided with the opportunity to design the air bag cover skin portion with a textured surface that may either be the same as or distinctly different from that of the main body skin portion. A stylist may accomplish this by so texturing the different areas on the mold surface the skin portions are cast against.

These and other aspects and features of the present invention will become more apparent from the following description and drawings:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an automotive air bag cover panel having a skin according to the present invention;

FIG. 2 is an enlarged view taken along the line **2—2** in FIG. **1** and includes a diagrammatic view of an air bag unit mounted behind the air bag cover portion of the panel;

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FIG. 3 is a perspective view illustrating air bag deployment through the air bag cover portion of the panel in FIG. 1,

FIG. 4 is a view like FIG. 2 but showing a different form of tear seam;

FIG. 5 is a diagrammatic partially cut-away front view with parts broken away of a shell mold and powder box apparatus for simultaneously casting both the main body skin portion and the air bag cover skin portion of the skin in FIG 1;

FIG. 6 is a view showing the apparatus in FIG. 5 inverted and illustrating the main body skin portion and the air bag cover skin portion of the skin being formed together on the shell mold;

FIG. 7 is a view taken along the line 7—7 in FIG. 5 with parts broken away;

FIG. 8 is a diagrammatic view illustrating the main body skin portion and the air bag cover skin portion being bonded together on the shell tool following their casting;

FIG 9 is a diagrammatic view illustrating the tear seam strip in FIGS. 1 and 2 being formed on the shell tool in the tear seam defining gap in the air bag cover skin portion following the casting of the latter;

FIG. 10 is a diagrammatic view showing the hidden tear seam in FIG. 4 being formed in the air bag cover skin portion following the casting of the latter;

FIG. 11 is a diagrammatic partially cutaway front view of a second shell mold assembly with a first powder box attached for casting a first plastic material to form the main body skin portion of the skin in FIG. 1;

FIG. 12 is a view showing the apparatus in FIG. 11 inverted and illustrating the first plastic material skin casting being formed on the shell mold;

FIG 13 is a diagrammatic partially cutaway front view of the second shell mold assembly with a second powder box attached for casting a second plastic material or for spraying a material to form the air bag cover skin portion of the skin in FIG. 1; and

FIG. 14 is a view showing the apparatus in FIG. 13 inverted and illustrating the second plastic skin casting being formed on the shell mold.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1–3 illustrate an automotive instrument panel 10 comprising a soft, thin, pliable shell or skin 12, a substantially rigid substrate 14 and a soft foam backing layer 16 for the skin 12 that is bonded to both the skin 12 and substrate 14. The skin 12, foam 16, and substrate 14 may be bonded or joined together by any molding process known in the art, e.g., foam-in-place, vacuum forming, injection molding, compression molding, reaction injection molding, thermoforming, steam chest molding or blow molding. The substrate 14 supports the panel shape and allows it to attach to the forward end of a vehicle passenger compartment by various attaching portions (not shown) molded in the substrate 14. The substrate 14 is formed of a high strength plastic material and can be injection molded. For example, a suitable high strength injection moldable plastic such as Dow Pulse, ARCO Dylark, GE Noryl, can be used to form the substrate 14. Other materials that may be used to construct the substrate 14 include metal, plastic composite or wood fiber composite using other forming techniques well known in the art. The foam backing layer 16 is formed of a soft durable plastics foam material such as polyurethane

foam, polyvinyl chloride foam, polyester foam, polystyrene foam, and polyolefin foam.

The skin **12** comprises a main body skin portion **20** and an air bag cover skin portion **22** made of a different plastic material better suited for the requirements of an air bag cover that must tear open as an air bag deploys through it. The main body skin portion **20** covers most of the instrument panel. The air bag cover skin portion **22** covers an air bag deployment portion of the instrument panel **10** on the passenger-side that covers an inflatable air bag system **24** and includes an air bag deployment door **32**. The two skin portions **20, 22** are joined together by a plastic bond **25**. The bonding material may or may not be the same material used to form the main body skin portion **20** or the air bag cover skin portion **22** or may be a composition of the two. The bonding material may be formed by overlapping and melt fusing the skin portions **20, 22** together, or may be applied separately as explained in greater detail below. Where the bonding material is applied separately, it must be of a form and composition capable of adequately bonding the main body and air bag cover portions **20, 22** of the skin **12** as is well known in the art. Preferable bonding materials include powder or liquid thermoplastic or thermoset compositions containing vinyls (typically PVC) or urethanes. Other bonding materials may include olefins, esters, styrenes and rubbers in various compositions.

The air bag system **24** is of a conventional type and includes an inflatable air bag **24A** that is inflated by a gas generator **24B** in response to a signal from a controller **24C** with a collision sensing device **24D** as is well known in the art.

The main body skin portion **20** is made of a first cast plastic material, e.g., a Drysol compound such as DL**1011** or DL**1013**. DL**1011** and DL**1013** are Textron Automotive proprietary formulations of PVC resins, plasticizers, stabilizers and pigments. Their formulations include 50 to 60% PVC resin by weight, 30 to 45% plasticizer by weight and 0.1 to 5% pigment by weight. The glass transition temperature of DL**1011** and DL**1013**, i.e., the temperature where DL**1011** and DL**1013** become brittle, is in the range of −50 to −55 degrees C.

The air bag cover skin portion **22** is made of a second cast plastic material that remains ductile at low temperatures substantially below where the first plastic material becomes brittle. The air bag cover skin portion **22** may, for example, comprise a polyurethane (PU) compound that may include a thermoplastic or thermoset aliphatic or aromatic compound. For example, U.S. patent application Ser. No. 08/319,614 discloses a suitable thermoplastic aliphatic compound and is incorporated herein by reference.

The main body and air bag cover skin portions **20, 22** may be formed simultaneously in a powder casting process as described in detail later. The main body portion **20** of the skin **12** covers most of the area of the panel **10** as mentioned above. The panel **10** includes an instrument cluster accommodating section **26**, an accessories accommodating console section **27** and a glove box accommodating section **28**. The instruments section **26** is located in a driver-side location on the panel for accommodating a cluster of instruments in front of a driver. The console section **27** is located in a central or intermediate location on the panel for accommodating various accessories such as temperature controls, a radio, etc. The glove box accommodating section **28** is located in a passenger-side location on the panel below the air bag cover portion of the panel covering the air bag **24A**.

The air bag cover skin portion **22** is located in a passenger side location on the panel and has a generally rectangular

shape that generally matches the shape of the air bag deployment portion of the panel **10**. A centrally located, U-shaped hidden tear seam **30** is disposed in an air bag deployment region **31** of the air bag cover skin portion **22**. When torn, the tear seam **30** forms a rectangular-shaped opening in the air bag cover skin portion **22** through which the air bag **24A** can deploy into the passenger compartment in front of a passenger seated on that side.

The air bag deployment door **32** is disposed in the substrate **14** and allows the air bag to deploy through the panel structure from behind the air bag cover skin portion **22**. The door **32** is connected to the main body of the substrate **14** by a hinge **33** and may be made of the same material as the substrate **14** as shown or a different material such as metal. The door **32** may be supported on a ledge **34** of the substrate **14** against inward movement to maintain the shape of the panel at this location and is directly impacted by the air bag **24A** on inflation. The foam layer **16** may remain continuous at this location as shown or be provided with a separated section that is bonded to the inner side of the door **32** and the air bag cover skin portion **22** within the area the tear seam **30** encompasses.

The tear seam **30** is formed of a material that is substantially weaker than the air bag cover skin. portion **22** (i.e. has a lower tensile strength, tear strength, or percent elongation as measured at break), e.g., a polyurethane (PU) or PVC material with a weakening filler material that reduces the strength of the tear seam strip **30** to substantially less than that of the material forming the air bag cover skin portion **22**. The tear seam **30** is adapted to be torn together with the foam layer **16** by the force of the inflating air bag **24A** acting on the substrate door **32**. A torn section **35** of the foam layer **16** and a torn section **36** of the cover skin portion **22** then swing outward with the hinged substrate door **32** to form a panel opening. The panel opening allows the inflating air bag **24A** to deploy, as shown in FIG. **3**, in a collision. Because the air bag deployment region **31** and tear seam **30** are located at or near the center of the air bag cover skin portion **22** and are therefore remote from the PVC main body skin portion **20**, the force of the inflating air bag **24A** cannot fragment the latter when the air bag deployment opening forms in the air bag cover skin portion **22**.

As seen in FIGS. **1** and **2**, the main body skin portion **20** and air bag cover skin portion **22** are cast with closely adjacent inner and outer edges **38** and **40**, respectively, for the formation of the bond **25**. The outer edge **40** defines the periphery of the air bag cover skin portion **22** and the inner edge **38** defines a border within the main body skin portion **20** surrounding the air bag cover skin portion **22**.

The main body skin portion **20** and air bag cover skin portion **22** are cast in the same mold at the same time using the shell tool and powder box apparatus **50** shown in FIGS. **5**, **6** and **7**. A second embodiment of the powder box apparatus **50** having two separate powder boxes **54'A**, **54'B** is generally shown at **50'** in FIGS. **11–14**. Reference numerals with the designation prime (') in FIGS. **11–14** indicate alternative configurations of elements that also appear in the first embodiment. Where a portion of the following description uses a reference numeral to refer to the figures, if that reference numeral carries no prime designation, I intend that portion of the description to apply equally to elements indicated by primed numerals in FIGS. **11–14**.

The apparatus **50** comprises a shell tool **52** and a partitioned powder box **54** having peripheral flanges **56** and **57**, respectively, by which the shell tool **52** and powder box **54** are adapted to be connected together in sealed relationship

about their periphery by suitable clamps in a well known manner. It should be understood that while the term "powder box" implies the use of a powdered form of material, the material form could also comprise that of pellets, beads, or liquid.

The shell tool **52** has an electroformed nickel mold surface generally designated as **58** that is formed in a well known manner and defines the desired shape of the entire skin **12** including the main body skin portion **20** and the air bag cover skin portion **22**. These skin portions **20**, **22** are formed on partitioned first **60** and second **62** surface area portions, respectively, of the shell tool mold surface **58**. The shape of the main body skin portion **20** and/or the air bag cover skin portion **22** may include certain style lines. In this case the mold surface **58** is provided with features for forming the style lines in the outer side of the skin **12**. The mold surface **58** is formed with a desired texture such as a grained texture that is imparted to the outer surface of the skin **12**. The texture of the main body skin portion **20** and the air bag cover skin portion **22** can be made the same or different in electroforming the first **60** and second **62** mold surface area portions.

Inside the powder box **54** a temperature-resistant joint-defining gasket **65** is mounted on a joint pattern/partition **64**. The joint pattern/partition **64** presses the joint-defining gasket **65** against the mold surface **58** to separate the powder box interior and shell tool **52** into two separate chambers **66** and **68** when the powder box **54** and shell tool **52** are clamped together. Partitioned sections **66A** and **68A** define these chambers in the mold box. The sections **66A**, **68A** are disposed on opposite sides of the joint pattern/partition **64** and are defined at the mold surface **58** by the respective first **60** and second **62** surface area portions of the shell tool **52**. Referring to FIGS. **5** and **7**, the joint-defining gasket **65** and at least the immediately supporting portion of the joint pattern/partition **64** are configured with the desired shape of the bonding joint **25** at the mold surface **58**. This causes the joint-defining gasket **65** to define a joint boundary between the first **60** and second **62** mold surface portions and also prevents plastic material from depositing onto the mold surface area that it covers. This leaves a narrow gap between the inner **38** and outer **40** edges of the skin portions **20**, **22**. The bond **25** will later be formed in this narrow gap while the two skin portions **20**, **22** remain on their respective mold surfaces **60**, **62**. The joint-defining gasket **65** can be a compressible temperature resistant foam or it can be a hollow gasket either of the inflatable or non-inflatable type as disclosed in U.S. Pat. No. 4,925,151.

The chamber **66** in the shell tool **52** and powder box assembly **54** is thus open only to the second surface area portion **62** of the shell tool **52** that defines the shape of the air bag cover skin portion **22** and its outer surface texture. The chamber **68** is thus open only to the first surface area portion **60** of the shell tool **52** that defines the shape of the main body skin portion **20** including any desired style lines as well as its outer surface texture. Referring again to FIGS. **5** and **7**, a tear seam pattern **70** is mounted by supporting struts **72A** and **72B** on the interior side of the joint pattern/partition **64** in the partitioned section **66A** of the powder box **54** that forms the chamber **66**. The tear seam pattern **70** extends into the shell tool **52** to a position closely adjacent to the second mold surface area portion **62** when the powder box **54** and shell tool **52** are clamped together. A temperature-resistant tear seam-defining gasket **74** having the desired shape of the tear seam **30** is mounted on the pattern **70**. The pattern **70** presses the tear seam-defining gasket **74** against the air bag cover skin mold surface **62** to

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form a narrow tear seam-defining gap when the plastic powder is cast against this surface to form the air bag cover skin portion 22 as described in more detail later. Similar to the joint-defining gasket 65, the tear seam-defining gasket 74 can be a compressible temperature resistant foam or it can be a hollow gasket either of the inflatable or non-inflatable type such as disclosed in the above U.S. Pat. No. 4,925,151.

A coat of paint may cover an outer surface of both the skin portions 20, 22, the bond 25 and the tear seam strip 30, hiding both the bond 25 and the tear seam strip 30 from view.

We intend the above description of the use of the skin 12 on an instrument panel to be illustrative and not limiting. In other embodiments, the skin 12 may be employed over any automotive panel or thin structure that an air bag deployment assembly is mounted behind, e.g., door panels, consoles, headliners, seats, pillars, other sidewall trim and package trays. In addition, instead of the hinged panel shown at 14 in FIGS. 2 and 4, the air bag deployment door may comprise a simple opening in the automotive panel, or any other means of forming or providing an air bag passageway or path. Instead of being made of urethane, the air bag cover portion 22 may be made of a PVC material, e.g., a Drysol compound such as DL3020, having the property of remaining substantially more ductile with decreasing temperature than the first PVC material DL3020 is made by Teknor Apex under the product designation code 93-A091C-59. DL3020 includes low temperature plasticizers such as azelates and trimellitates that yield a low glass transition temperature in the final polymer, i.e., from −60 to −70 degrees C. However, cost aside, PU compounds are generally preferred for use over PVC compounds given the plasticizer migration and associated loss of ductility from PVC over long periods of time. PU compounds are also preferred because they generally tend to have a wider temperature performance range than PVCs, at both high and low temperatures. In other embodiments, instead of, or in addition to being made of PU or PVC, the air bag cover portion 22 composition may include other vinyls, olefins (e.g , PP, PE, TPO, ETP-TPO), esters (e.g., COPE), styrenes (e g , ABS, ASA), and rubbers (e.g TPO, ETP-TPO, ABS)

As an additional alternative, the air bag cover portion 22 may be formed from a plastic material, which is applied by spraying.

In other embodiments, instead of, or in addition to being made of PVC, the main body skin composition may include other vinyls, urethanes (e.g , PU) olefins (e.g., PP, PE, TPO, ETP-TPO), esters (e.g., COPE), styrenes (e.g., ABS, ASA), and rubbers (e.g. TPO, ETP-TPO, ABS)

Other embodiments may also include a tear seam pattern 70 with an X, H, I or C-shape rather than a U-shape. These tear seam patterns may be defined by an integral tear seam strip 30 disposed in the air bag deployment region 31 of the air bag cover skin portion 22 or, as shown in FIGS. 4 and 10, a groove 102 in the back side of the air bag cover skin portion 22. Instead of comprising a PU material with a weakening filler material, the tear seam strip 30 may instead comprise a "weakened" thermoplastic PVC material, e.g., Drysol compound DL3021, which will reduce the strength of the tear seam strip 30 to substantially less than that of the second thermoplastic PVC material. DL3021 is a blend of 80% DL3020 by weight and 20% filler material by weight. In other embodiments, instead of, or in addition to being made of PU or PVC, the tear seam strip 30 composition may include other vinyls, olefins (e.g., PP, PE, TPO, ETP-TPO), esters (e.g., COPE), styrenes (e g., ABS, ASA), and rubbers (e g TPO, ETP-TPO, ABS)

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A process for manufacturing the skin 12 for the air bag cover panel includes initially removing the powder box **54** from the shell tool **52** and depositing a charge **80** of powder in the bottom of the partitioned section **66**A of the powder box **54** that forms the chamber **66** and a charge **82** of the first plastic material in the bottom of the partitioned section **68A** of the powder box **54** that forms the other chamber **68**. The charged powder box **54** and the shell tool **52** are then joined as shown in FIG. **5** and the shell tool **52** is heated to a sufficient temperature to cause approximately one millimeter of the two dry powders **80, 82** to attach and fuse to the shape of the mold surface portions **60** and **62** when these powders are cast against these surfaces. The shell tool **52** is heated to this temperature in a well-known manner such as by circulating heated air across its exterior.

The mold apparatus **50** is then rotated or inverted as a unit 180 degrees from the position shown in FIG. **5** to the position shown in FIG. **6** to dump or cast the first dry plastic material **82** against the first heated mold surface area portion **60** and at the same time deposit the second powder **80** on the second heated mold surface area portion **62**. A layer of the two different powders forms across the surface of the respective mold surface portions **60** and **62** separated by the joint-defining gasket **65**. In addition, the second powder layer **80** in the chamber **66** on the second mold surface portion **62** forms about the tear seam-defining gasket **74**. The layer of the two different powders **80, 82** fuses from the heat of the mold surface **58** to the desired thickness determined by the prescribed heat level of the shell tool **52** to form the main body skin portion **20** and the air bag cover skin portion **22**. The two cast skin portions **20, 22** are separated by the joint-defining gasket **65** which forms a narrow joint-defining gap **84** between the adjacent inner **38** and outer **40** skin-casting edges at the shell tool mold surface **58** (see FIG. **8**). In addition, the layer of powder extending about the tear seam defining gasket **74** on the mold surface **62** in the chamber **66** fuses to form a narrow tear seam-defining gap **86** in the cover skin casting following removal of this gasket (see FIG. 9).

Following fusing, the remaining powder **80, 82** is dumped back into the powder box **54** by rotating the apparatus **50** as a unit back to its initial position and the powder box **54** with the gaskets **65** and **74** and the joint pattern/partition **64**, with the tear seam pattern **70** attached, is then separated from the shell tool **52**. The shell tool **52** alone is then inverted again, as shown in FIG. **8**, with the fused skin portions **20** and **22** remaining on the shell tool **52**. The bonding material **88** is then sprayed from a nozzle **90** into the gap **84** between the main body skin portion inner edge **38** and the air bag cover skin portion outer edge **40**. The bonding material **88** fills the gap **84** and preferably covers the margins on the backside of these skin portions **20, 22** bordering the gap **84**. This forms a bond **25** to connect these skin portions **20, 22** together while they are still on the shell tool **52**.

Where the bonding material **88** is sprayed-on, it would preferably have a form and composition capable of adequately bonding to both the materials making up the main body skin portion **20** and the airbag cover skin portion **22**. Typically, the bonding material **88** would include either the material making up the main body skin portion **20**, the airbag cover skin portion **22**, or both, given the proposition that similar materials generally bond to themselves. Preferably, the form of the material as applied is either that of a powder or liquid, which may be, applied though a conventional spray gun or spray apparatus. The plastic material(s) contained in either the powders or liquids may be of a completely thermoplastic nature or may contain a

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chemically reactive component, which makes them partially, or completely thermoset after cure. In the instance of initially liquid bonding materials, the plastic bonding material may or may not be required to be in solution (either aqueous or non-aqueous), in order to make the plastic bonding material capable of being sprayed Examples of preferable plastic bonding materials include both powder and liquid vinyls and urethanes. In order to spray liquid PVC it typically must be provided in a non-aqueous solution. Conversely, sprayable reactive liquid urethanes are not necessarily required to be in solution given that the reactive components are normally liquids and capable of being sprayed. Other bonding materials may include olefins, esters, styrenes and rubbers in various compositions.

A relatively weak material **92** is also then applied from a nozzle **94** as shown in FIG. **9** to fill the gap **86** and form the tear seam **30** as an integral tear seam strip **30** in the air bag cover skin portion **22**. While the tear seam strip **30** depicted in FIG. **9** does not overlap the main body skin portion **20** or the airbag cover skin portion **22**, overlapping of the main body skin portion **20** and/or airbag cover skin portion **22** is also possible. Overlapping will promote adequate bonding through increased surface area Preferably, the tear seam strip **30** is made of a material having low temperature ductility but with its strength sufficiently reduced so that it will tear with the force of air bag **24A** inflation. Examples include PU or DL**3020** sufficiently weakened by adding a weakening filler such as nepheline syenite with a medium particle size of about 3.9 microns and/or hollow silica-alumina microspheres with a median particle size of about 1.6 microns with the filler constituting about 60–80% of the tear seam material by weight. The addition of filler material weakens the compound by reducing the proportional amount of binder present in the compound. Examples of other weakened tear strip materials include various plastics such as olefins, esters, styrenes, and rubbers combined with fillers such as ceramics, minerals other plastics, or glass.

In distinct structural contrast, the bond **25** that joins the skin portions **20** and **22** has much greater strength. The bond **25** has sufficient strength to hold these different skin portions **20**, **22** together and, in particular, to prevent the air bag force from separating the air bag cover skin portion **22** from the main body skin portion **20**. However, in other embodiments, the bond **25**, or a portion of the bond **25**, and the tear seam **30** may be one and the same. According to such an alternative embodiment the composition of the bonding material **88** used for the bond **25** that joins skin portions **20** and **22** would be of a relatively weaker material An example of this weaker material is the material **92** that would ordinarily be used to fill the gap **86** and form the tear seam **30** as an integral tear seam strip **30**.

The shell tool **52** is further heated to suitably melt fuse and/or cure both the initially-deposited plastic skin materials **80**, **82** and the later-added plastic bonding material **88** and tear seam material **92**. Finally, the shell tool **52** is cooled and the skin **12** with its simultaneously cast main body skin portion **20** and air bag cover portion **22** bonded together by the bond **25** and with the inclusion of the tear seam **30** in the air bag cover skin portion **22** is removed as a single piece from the shell tool **52**. Following removal from the shell tool, the skin **12** is then assembled in a well-known manner with the foam layer **16** and substrate **14** to complete the panel. At this time the tear seam **30** may be hidden from view by applying a coat **100** of suitable paint to the air bag cover skin portion **22** or the whole skin **12** may be painted to hide both the tear seam **30** and the joint bond **25** from view. Alternatively, the coat **100** of paint may be applied before assembly to the foam layer **16** and substrate **14**.

The tear seam in the air bag cover skin casting **22** may also be formed as a hidden tear seam defining groove **102** in the back side of this skin casting as shown in FIGS. **4** and **10** thus eliminating any need to paint the air bag cover skin to hide the existence of a tear seam like the tear seam strip **30** in FIGS. **1–3**. The tear seam defining groove **102** is formed with a heated impression tool or hot knife **104** as illustrated in FIG. **10** wherein the tool has a pattern **106** having the desired configuration of the tear seam and is formed with a rounded knife edge that is pressed against the cover skin casting to melt the plastic and form the groove to the desired depth. Alternatively, the knife-edge may be sharp (not shown). The hidden groove may also be formed by scoring with a laser or suitable cutting apparatus rather than a heated impression tool. The groove may also be formed as disclosed in U.S. Pat. No. 5,072,967, assigned to the assignee of the present invention and incorporated herein by reference.

The air bag cover skin casting **22** may be left devoid of any tear seam and a suitable cutter may instead be mounted in a position to form the air bag deployment opening in the air bag cover skin portion **22** upon air bag inflation. In this case the cutter is operated by the force of the inflating air bag **24**A to cut an opening in the central region of the air bag cover skin portion **22**. For example, the cutter disclosed in U.S. Pat. No. 5,108,128, which is hereby incorporated by reference, could be used in the panel construction to form the air bag deployment opening in the air bag cover skin portion **22**. These and other suitable methods of weakening the skin to form tear seams are described in detail in U.S. Pat. Nos. 5,256,354; 5,288,103; 5,443,777; 5,154,444; 5,131,678; 5,222,760; 5,035,444; 5,072,967; 5,108,128 and 5,092,208; assigned to the assignee of the present invention and incorporated herein by reference.

FIGS. **11–14** show a second embodiment of the shell tool apparatus **50'** used to manufacture a skin according to a second process. In this second process, instead of casting the main body skin portion **20** and air bag cover skin portion **22** at the same time from the same powder box **54**, the main body skin portion **20** may be cast first—before casting the air bag cover skin portion **22**. The second surface area portion **62'** of the shell tool **52'** is first masked-off with a silicone or pinular insulator **110** as shown in FIG. **11**. A first material **82'** is then cast from a first powder box **54'**A against the first surface area portion **60'** as shown in FIG. **12**. The second surface area portion **62'** is then unmasked as shown in FIG. **13**, and a second material **80'** is cast from a second powder box **54'**B against the second surface area portion **62'** as shown in FIG. **14**. The second material **80'** may also be cast against the material **82'** coating the first surface area portion **60'** to form an overlap.

As shown in FIGS. **13** and **14** the second material is cast about an X-shaped tear seam-defining gasket **74'** supported by an anvil **112** within the second powder box **54'**B. The tear seam-defining gasket **74'** may alternatively have either an H, I, C or U-shape. The tear seam-defining gasket **74'** is pressed against the second surface area portion **62'** when the second powder box **54'**B is connected to the shell tool **52'**. The tear seam-defining gap **86** in the air bag cover skin portion **22** is left vacant when the tear seam-defining gasket **74'** is removed. A plastic material is then sprayed, cast or otherwise used to fill the gap **86** and forms a tear seam strip **30** in the plastic skin casting **12** while this casting remains on the second surface area portion **62'**.

In another embodiment the second powder box **54'**B may be eliminated and the second material **80'** may be sprayed against the second surface area portion **62'**. The second

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